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NEW TECHNOLOGY FOR WATER POLLUTION CONTROL

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NEW TECHNOLOGY FOR WATER POLLUTION CONTROL

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REFERENCE MATERIALS

The following Research, Development, and Demonstration Grant, Contract, and in-house project reports which relate to the subjects discussed are available from The National Technical Information Service, Department of Commerce, Springfield, Virginia 22151, (paper copies - $3.00 and $6.00, microfiche copies - $0.95) or at the Government Printing Office, Washington, D.C. 20402, at the designated sale price. Further inquiries concerning these reports should be directed to the Project Reports System, Office of Research and Development, Water Quality Office, Environmental Protection Agency, Washington, D.C. 20242.

Report Number	Title/Author	Source
10000---04/70	Research, Development, and Demonstration Projects - Division of Applied Science and Technology; by FWQA, Washington, D.C.	PB 192 091
11000---01/70	Storm and Combined Sewer Demonstration Projects - January 1970; by Storm and Combined Sewer Branch, Division of Applied Science and Technology, FWQA, Washington, D.C.	PB 190 799
11020EKO10/69	Combined Sewer Separation Using Pressure Sewers; by American Society of Civil Engrs., Cambridge, Mass.	PB 188 511
11023EVO06/70	Microstraining and Disinfection of Combined Sewer Overflows; by Cochrane Div., Crane Co., King of Purssia, Pa.	GPO - 70¢
11024---06/70	Combined Sewer Overflow Abatement Technology; Storm and Combined Sewer Pollution Control Branch, Division of Applied Science and Technology, FWQA, Washington, D.C.	GPO - $2.50
12000---01/70	Projects of the Industrial Pollution Control Branch; by Industrial Pollution Control Branch, Div. of Appl. Science and Technology, FWQA Washington, D.C.	PB 189 766
12000---07/70	Projects of the Industrial Pollution CControl Branch, July 1970; by Industrial Pollution Control Branch, Div. of Appl. Science and Technology, FWQA, Washington, D.C.	GPO - $1.75
12060---10/69	Current Practice in Potato Processing Waste Treatment; by Univ. of Washington, Seattle, Washington	GPO - $1.00

Report Number	Title/Author	Source
12060---04/70	Proceedings First National Symposium on Food Processing Wastes; by FWQA, USDA, National Canners Assoc., and Northwest Food Processors Assoc.	(at press)
12060FAD10/69	Aerobic Treatment of Fruit Processing Wastes; by Snokist Growers, Yakima, Washington	PB 188 506
13030ELY12/69	Collected Papers Regarding Nitrates in Agricultural Waste Waters; by FWQA, San Francisco, California, U.S. Bureau of Reclamation, and California Department of Water Res.	GPO - $1.50
14010DMO03/70	New Mine Sealing Techniques for Water Pollution Abatement; by Halliburton Co., Duncan Okla.	GPO - $1.50
14010DYK03/70	Treatment of Acid Mine Drainage by Reverse Osmosis; by Rex Chainbelt, Inc., for the Commonwealth of Pennsylvania	GPO - 55¢
14010DZM08/70	Feasibility Study of Mining Coal in an Oxygen Free Atmosphere; by Island Creek Coal Co., Holden, W.V. and Cyrus Wm. Rice Div., NUS Corp., Pittsburgh, Pa.	GPO - $1.50
14010EIZ01/70	Limestone Treatment of Acid Mine Drainage; by Bituminous Coal Research, Inc., Monroeville, Pa.	GPO - $1.25
15080EOS10/70-1	Evaluation of Selected Earthmoving Equipment for the Restoration of Oil Contaminated Beaches; by URS Research Co., San Mateo, Calif.	GPO - $1.50
17010---01/70	Treatment Techniques for Removing Phosphorus from Municipal Wastewaters; by J.J. Convery, Advanced Waste Treatment Research Laboratory, FWQA, Cincinnati, Ohio	(at press)
17010DHT09/70	Methanol Requirement and Temperature Effects in Wastewater Denitrification; by Gulf South Research Institute, New Iberia, La.	(at press)
17010DRD07/70	A Study of Nitrification & Denitrification; by Aerojet General Corp., El Monte, Calif.	GPO - $1.00
17010EDO06/70	Phosphorus Removal Using Chemical Coagulation and a Continuous Countercurrent Filtration Process; by Johns-Manville Products Corp., Manville, N.J.	GPO - 65¢

Report Number	Title/Author	Source
17020---12/68	A Comparison of Expanded-Bed and Packed-Bed Adsorption Systems; by FMC Corporation	PB 187 756
17020DVJ05/69	Appraisal of Granular Carbon Contacting: Phase I & II Phase III by Swindell-Dressler Co., Pittsburgh, Pa.	 PB 190 168 PB 190 167
17050DAL05/70	Granular Carbon Treatment of Raw Sewage; by FMC Corp.	GPO - $1.00
17050DNW05/70	Investigation of the Use of High-Purity Oxygen Aeration in the Conventional Activated Sludge Process; by Union Carbide Corp., Linde Div., Tonawanda, N.Y.	PB 194 241
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INTRODUCTION

IF THE DECADE OF THE SEVENTIES IS TRULY TO BE THE "AGE OF AQUARIUS," IT MUST BE A DECADE OF ACTION TO CONTROL AND PREVENT WATER POLLUTION AND TO RESTORE THE QUALITY OF THE WATERS OF THE WORLD. PRESIDENT NIXON HAS RECOMMENDED THAT WE IN THE UNITED STATES SPEND $12 BILLION FOR THE CONSTRUCTION OF MUNICIPAL POLLUTION CONTROL FACILITIES DURING THE NEXT SEVERAL YEARS WITH A RE-EVALUATION OF THE RESOURCE REQUIREMENTS TO BE MADE IN 1973. THE COSTS INVOLVED IN CONTROLLING ALL SOURCES OF WATER POLLUTION, MUNICIPAL, INDUSTRIAL, AGRICULTURAL, MINING AND OTHER SOURCES, HAVE BEEN ESTIMATED TO BE ON THE ORDER OF $60 BILLION IN THE UNITED STATES. WHILE THESE SOUND LIKE, AND IN FACT ARE, TREMENDOUS INVESTMENTS, THEY REPRESENT, IN PERSPECTIVE, CAPITAL EXPENDITURES OF ONLY SOME $60 PER CAPITA FOR MUNICIPAL SOURCES AND ABOUT $300 PER CAPITA FOR ALL SOURCES PUT TOGETHER. THESE INVESTMENTS WOULD ALSO BE SPREAD OVER A NUMBER OF YEARS. THESE COSTS CAN, AND, IN FACT, SHOULD BE COMPARED WITH THE CURRENT PER CAPITA INVESTMENTS IN OTHER UTILITIES SUCH AS GAS ($125/CAPITA), PHONE ($310/CAPITA), ELECTRIC ($433/CAPITA) AND IN FEDERAL HIGHWAYS ($618/CAPITA).

A NATIONAL COMMITMENT OF THIS MAGNITUDE AND AN INTERNATIONAL COMMITMENT OF SIGNIFICANTLY GREATER MAGNITUDE PRESENT A UNIQUE NEW CHALLENGE TO INDIVIDUALS INVOLVED IN ENVIRONMENTAL QUALITY CONTROL AND PARTICULARLY IN RESEARCH. THE CHALLENGE IS TO GO ONE STEP FURTHER AND NOT JUST DO RESEARCH, BUT ACTIVELY PROMULGATE RESEARCH FINDINGS TO THE USERS OF THIS TECHNOLOGY--AND, MOREOVER, NOT JUST PROMULGATE ISOLATED

RESEARCH RESULTS OF LIMITED SCOPE BUT TO TRANSFER COMPLETE "PACKAGES OF TECHNOLOGY" TO THE USER COMMUNITY. PACKAGED TECHNOLOGY WOULD INCLUDE AN ARRAY OF PROCESS ALTERNATIVES AVAILABLE FOR TREATING A SPECIFIC WASTE, COST AND PERFORMANCE INFORMATION ON THE TOTAL WASTEWATER TREATMENT SYSTEM, INCLUDING CONSIDERATION OF THE ULTIMATE DISPOSAL OF BRINES AND SLUDGES, OPERATING REQUIREMENTS AND DESIGN GUIDELINES. THE MOST COST-EFFECTIVE TECHNOLOGICAL DEVELOPMENTS POSSIBLE FOR APPLICATION IN THE IMMEDIATE AND NEAR-TERM FUTURE MUST BE IDENTIFIED.

IN OCTOBER OF 1970 A SPECIAL PROGRAM WAS ANNOUNCED IN THE UNITED STATES TO TRANSFER, NOT JUST DISSEMINATE, THE RESULTS OF RESEARCH TO THE POTENTIAL USERS OF NEW POLLUTION CONTROL TECHNOLOGY. THIS "TECHNOLOGY TRANSFER PROGRAM" IS DESIGNED TO DEMONSTRATE CONVINCINGLY THE TECHNICAL AND ECONOMIC PRACTICABILITY AND THE RELIABILITY OF RESEARCH FINDINGS. THE AUDIENCE IS COMPOSED OF BOTH THE TECHNICIAN, I.E., THE DESIGN ENGINEER, THE TREATMENT PLANT OPERATOR, ETC., AND THE NON-TECHNICIAN DECISION-MAKER, I.E., THE MAYOR, THE LEGISLATOR, THE REGULATORY OFFICIAL, ETC. OUR OBJECTIVE IS TO INSURE THAT THE LATEST TECHNIQUES ARE INCORPORATED INTO THE DESIGN OF TREATMENT AND CONTROL FACILITIES WHICH WILL BE CONSTRUCTED IN THE NEXT SEVERAL YEARS. THE TECHNOLOGY TRANSFER PROGRAM UTILIZES A VARIETY OF COMMUNICATIONS TECHNIQUES: LARGE PRESENTATIONS FOR GENERAL AUDIENCES, TECHNICAL SEMINARS FOR FEDERAL, STATE AND LOCAL OFFICIALS, DESIGN WORKSHOPS FOR SMALL GROUPS OF CONSULTING ENGINEERS, PUBLICATION OF DESIGN MANUALS, USE OF FILM-STRIPS AND VIDEO TAPE PRESENTATIONS PLUS TOURS AND LECTURES AT DEMONSTRATION FACILITIES ACROSS THE COUNTRY WHERE ADVANCED WASTE TREATMENT

AND POLLUTION CONTROL METHODS ARE IN FULL-SCALE OPERATION. PRIMARY EMPHASIS IS CURRENTLY BEING GIVEN TO THE MUNICIPAL SEWERED WASTE PROBLEM SINCE THIS IS THE AREA WHERE THE GREATEST "ACTION-EFFECTIVENESS"* CAN BE ACHIEVED.

MUNICIPAL SEWERED WASTES

MUNICIPAL WASTES INCLUDE COMBINED DOMESTIC AND INDUSTRIAL WASTE DISCHARGES WHICH CHARACTERISTICALLY ARE A LARGE SOURCE OF DEGRADABLE ORGANIC MATERIAL, BACTERIA AND VIRUSES AND WHICH CONTAIN NUTRIENTS THAT ACCELERATE EUTROPHICATION OF RIVERS, LAKES AND ESTUARIES. MAJOR EMPHASIS IN THIS AREA HAS BEEN DIRECTED TOWARD DEMONSTRATION OF LOWER COST AND MORE EFFICIENT METHODS OF REMOVING ORGANICS, PHOSPHORUS AND NITROGEN.

MORE THAN A DOZEN CHEMICAL TREATMENT SYSTEMS FOR THE REMOVAL OF PHOSPHORUS AS WELL AS BOD AND SUSPENDED SOLIDS ARE AVAILABLE TODAY FOR FULL-SCALE APPLICATION. SYSTEM ALTERNATIVES INCLUDE THE CHOICE OF CHEMICAL COAGULANT (IRON, ALUM OR LIME) AND THE POINT OF CHEMICAL ADDITION (TO PRIMARY, SECONDARY OR TERTIARY PROCESSES). FACTORS AFFECTING THE CHOICE OF CHEMICAL AND POINT OF ADDITION ARE INFLUENT PHOSPHORUS LEVEL, EFFLUENT DISCHARGE REQUIREMENT, WASTEWATER CHARACTERISTICS SUCH

* ACTION-EFFECTIVENESS - A QUALITATIVE ASSESSMENT OF POLLUTION PROBLEM AREAS WHICH COMBINES THE RELATIVE COST OF CONTROL, ACCOMPLISHMENT IN MEETING STANDARDS, AVAILABILITY OF TECHNOLOGY AND WILLINGNESS AND ABILITY TO PROCEED.

AS ALKALINITY AND PH, PLANT SIZE, LOCAL COST OF CHEMICALS, SLUDGE HANDLING FACILITIES, ULTIMATE DISPOSAL ALTERNATIVES AND THE CONVENTIONAL PROCESS UTILIZED. GENERALLY, A SYSTEM UTILIZING IRON OR ALUM ADDED BEFORE THE PRIMARY CLARIFIERS OR AERATORS IS SELECTED WHERE AN EFFLUENT REQUIREMENT OF I-2 MG/L P IS DESIRED AND THE INFLUENT PHOSPHORUS CONCENTRATION IS LOW TO MODERATE (~IO MG/L). AN EFFLUENT PHOSPHORUS CONCENTRATION OF 0.5 MG/L CAN BE ACHIEVED IF A SUPPLEMENTAL DOSE OF COAGULANT IS ADDED PRIOR TO A TERTIARY FILTRATION STEP. TOTAL OPERATING COSTS FOR CHEMICAL ADDITION TO THE PRIMARY OR SECONDARY STEP, INCLUDING AMORTIZATION OF THE CHEMICAL FEEDERS AND EXPANDED SLUDGE HANDLING EQUIPMENT, WILL BE $0.06-$0.08/1000 GAL. IN SOME LOCATIONS, IRON SALTS ARE AVAILABLE VERY CHEAPLY AS WASTE PICKLE LIQUOR; A SUBSTANTIAL REDUCTION IN CHEMICAL COSTS CAN BE ACHIEVED IF A RELIABLE SOURCE OF WASTE PICKLE LIQUOR IS AVAILABLE.

LIME TREATMENT OF RAW SEWAGE OR SECONDARY EFFLUENT WOULD OFTEN BE UTILIZED IN LARGER PLANTS (>IO MGD) WHERE THE ECONOMIES OF SCALE ARE SIGNIFICANT AND RECALCINATION IS ECONOMICALLY PRACTICABLE. LIME TREATMENT IS PARTICULARLY ADVANTAGEOUS WHEN THE INFLUENT ALKALINITY IS LOW AND THE INFLUENT PHOSPHORUS CONCENTRATION IS HIGH. EFFLUENT PHOSPHORUS CONCENTRATIONS OF 0.5 MG/L ARE ATTAINABLE WITHOUT FILTRATION AND 0.05 MG/L CAN EVEN BE ACHIEVED WITH FILTRATION. TOTAL OPERATING COST, INCLUDING AMORTIZATION OF THE CAPITAL INVESTMENT, FOR A IO-MGD TWO-STAGE LIME CLARIFICATION SYSTEM IS ABOUT $0.09/1000 GAL.

A NOVEL CHEMICAL TREATMENT SYSTEM WHICH HAS RECENTLY BEEN DEMONSTRATED IS THE MOVING BED FILTER (MBF). THE FILTER MEDIA, SAND, IS MECHANICALLY PULSED COUNTERCURRENT TO THE DIRECTION OF FLOW. THE ACCUMULATED SOLIDS

AND THE FILTER MEDIA IS MECHANICALLY GUILLOTINED AT THE FILTER SURFACE, WASHED TO SEPARATE THE FILTERED SOLIDS AND THE SAND IS RECYCLED TO THE BASE OF THE FILTER. FILTERED SOLIDS ARE GRAVITY THICKENED AND CAN BE DEWATERED ON A ROTARY PRECOAT FILTER. MBF HAS BEEN SUCCESSFULLY APPLIED TO ALUM-COAGULATED SECONDARY EFFLUENT, UNSETTLED TRICKLING FILTER EFFLUENT, PRIMARY EFFLUENT AND EVEN RAW SEWAGE. THE FILTER IS CAPABLE OF HANDLING HIGH AND VARIABLE SUSPENDED SOLIDS LOADS ON A CONTINUOUS BASIS. A 5-MGD PLANT IN MANVILLE, NEW JERSEY, USING THE MBF WITH ALUM COAGULATION IS IN OPERATION TO SIGNIFICANTLY UP-GRADE THE TRICKLING FILTER EFFLUENT QUALITY AND ACHIEVE 95% PHOSPHORUS REMOVAL. ADDITIONAL DEVELOPMENT WORK IS BEING CONDUCTED TO EVALUATE THE CONCEPT OF A SINGLE UNIT PHYSICAL-CHEMICAL SYSTEM USING THE MBF AND POWDERED ACTIVATED CARBON.

THE ENVIRONMENTAL PROTECTION AGENCY HAS CONTRACTED FOR THE PREPARATION OF A DESIGN MANUAL WHICH WILL PRESENT, IN ONE DOCUMENT, DESIGN GUIDELINES AND COST INFORMATION ON ALL THE ALTERNATIVE PHOSPHORUS REMOVAL TECHNIQUES CURRENTLY AVAILABLE. THE MANUAL WILL BE AVAILABLE BY THE END OF 1971.

HOW EXTENSIVELY IS CHEMICAL TREATMENT BEING APPLIED IN THE UNITED STATES? A PARTIAL LIST OF FULL-SCALE PLANTS UTILIZING CHEMICAL TREATMENT IS SHOWN IN TABLE I.

TABLE I

FULL-SCALE PLANTS
UTILIZING CHEMICAL TREATMENT

TREATMENT IN PRIMARY	FLOW MGD	CHEMICAL	STATUS
DETROIT, MICHIGAN	600	IRON	DESIGN
ROCHESTER, NEW YORK	100	LIME	CONST.
BAY CITY, MICHIGAN	12	IRON	CONST.
CLEVELAND, OHIO	10	IRON	DESIGN
PAINESVILLE, OHIO	5	IRON	DESIGN
HATFIELD TOWNSHIP, PA.	5	LIME	DESIGN
HOLLAND, MICHIGAN	4	LIME	CONST.
WYOMING, MICHIGAN	4	IRON	DESIGN
MENTOR, OHIO	2	IRON	ON-STREAM
MINERAL ADDITION TO AERATOR			
CHICAGO, ILLINOIS	30	IRON	DESIGN
SEATTLE, WASHINGTON	20	IRON & ALUM.	DESIGN
POMONA, CALIFORNIA*	2	ALUM. & SOD.AL.	COMPLETED
XENIA, OHIO*	1	ALUM.	COMPLETED
MANASSAS, VIRGINIA*	1	ALUM & SOD.AL.	COMPLETED
TEXAS CITY, TEXAS*	1	IRON & ALUM.	COMPLETED
TERTIARY TREATMENT			
SOUTH LAKE TAHOE, CALIF.	7.5	LIME	ON-STREAM
MANVILLE, NEW JERSEY	5	ALUM.	ON-STREAM
PISCATAWAY, MARYLAND	5	LIME	CONST.
COLORADO SPRINGS, COLO.	2	LIME	CONST.
SANTEE, CALIFORNIA	2	IRON & ALUM.	ON-STREAM

* R&D STUDIES

THE TOTAL OPERATING COSTS REPORTED FOR CHEMICAL TREATMENT CANNOT BE ATTRIBUTED ENTIRELY TO PHOSPHORUS REMOVAL SINCE A SUBSTANTIAL IMPROVEMENT IN THE REMOVAL OF ORGANICS AND SUSPENDED SOLIDS IS ACHIEVED SIMULTANEOUSLY. CHEMICAL CLARIFICATION OF RAW WASTEWATER WILL REMOVE FROM 70-80% OF THE ORGANICS AND 90-95% OF THE SUSPENDED SOLIDS. THESE RESULTS HAVE STIMULATED A GREAT DEAL OF INTEREST IN THE CONCEPT OF INDEPENDENT PHYSICAL-CHEMICAL (IPC) TREATMENT UTILIZING CHEMICAL CLARIFICATION AND GRANULAR CARBON ADSORPTION. IPC TREATMENT IS CAPABLE OF REMOVING 95-98% OF THE ORGANICS FROM MUNICIPAL WASTEWATER. THE PRODUCT, CONTAINING 6-12 MG/L OF TOTAL ORGANIC CARBON, IS SUITABLE FOR REUSE AS A HIGH QUALITY IRRIGATION SUPPLY, INDUSTRIAL SUPPLY OR PERHAPS, EVEN FOR BODY-CONTACT RECREATIONAL PURPOSES. THE TOTAL OPERATING COSTS FOR A 10-MGD IPC TREATMENT FACILITY ARE ESTIMATED TO BE $0.22/1000 GAL. WHICH COMPARES FAVORABLY WITH THE COST OF A CONVENTIONAL SECONDARY TREATMENT PLANT WITH PHOSPHORUS REMOVAL. MOREOVER, IPC TREATMENT OFFERS SEVERAL DISTINCT ADVANTAGES OVER CONVENTIONAL PRIMARY AND SECONDARY TREATMENT:

- REDUCED LAND REQUIREMENT -1/4 TO 1/2 OF LAND AREA FOR CONVENTIONAL TREATMENT
- GREATER FLEXIBILITY IN DESIGN AND OPERATION
- SUPERIOR ORGANIC REMOVAL CAPABILITY
- REDUCED SENSITIVITY TO DIURNAL FLOW AND LOAD VARIATIONS
- IMMUNITY TO SUBSTANCES TOXIC TO BIOLOGICAL SYSTEMS

A DESIGN MANUAL ON GRANULAR ACTIVATED CARBON ADSORPTION WILL BE AVAILABLE IN MID-1971. THIS MANUAL WILL PRESENT PROCESS DESIGN GUIDELINES, COST AND PERFORMANCE INFORMATION AND DISCUSS EQUIPMENT CONSIDERATIONS OF INTEREST TO THE DESIGN ENGINEER SUCH AS MODE OF CONTACTING (UPFLOW, DOWNFLOW, STATIC BED, FLUIDIZED BED), MATERIALS OF CONSTRUCTION (CONCRETE, STEEL), AND MODE OF OPERATION (GRAVITY, PRESSURE).

A LIST OF FULL-SCALE PLANTS WHICH WILL BE USING INDEPENDENT PHYSICAL-CHEMICAL TREATMENT IS SHOWN IN TABLE 2.

TABLE 2 - FULL-SCALE INDEPENDENT PHYSICAL-CHEMICAL PLANTS

LOCATION	FLOW	STATUS
NIAGARA FALLS, NEW YORK	60	PLANNED
CLEVELAND, OHIO	40	DESIGN
GARLAND, TEXAS	30	DESIGN
FITCHBURG, MASSACHUSETTS	15	DESIGN
ROCKY RIVER, OHIO	10	BIDS TAKEN
CORTLAND, NEW YORK	10	PLANNED
CLAY, NEW YORK	10	PLANNED
OWOSSO, MICHIGAN	6	DESIGN
PAINESVILLE, OHIO	5	DESIGN
WATERFORD, NEW YORK	2	PLANNED

NITROGEN REMOVAL CAPABILITY CAN BE INCORPORATED INTO THE TREATMENT SCHEME OF A PHYSICAL-CHEMICAL PLANT BY UTILIZING ONE OF THE RECENTLY-DEVELOPED AMMONIA REMOVAL TECHNIQUES SUCH AS BREAKPOINT CHLORINATION, OR AMMONIA AIR STRIPPING AT ELEVATED PH. THE LARGEST DEMONSTRATED NITROGEN REMOVAL PLANT IN THE U.S. IS THE 3.5 MGD, CROSS-FLOW AMMONIA STRIPPING TOWER AT LAKE TAHOE, CALIFORNIA. AIR STRIPPING, WHEN USED

IN CONJUNCTION WITH LIME PRECIPITATION OF PHOSPHATES, IS A RELATIVELY INEXPENSIVE PHYSICAL-CHEMICAL AMMONIA REMOVAL TECHNIQUE WHICH REQUIRES A CAPITAL INVESTMENT OF ONLY ABOUT $700,000 FOR A 10-MGD FACILITY. TOTAL OPERATING COSTS FOR A 10-MGD PLANT ARE APPROXIMATELY $0.04/1000 GAL. BECAUSE LARGE AIR FLOWS (200-400 FT^3/GAL) ARE REQUIRED, THE PROCESS IS TEMPERATURE-SENSITIVE AND FREEZING IS AN OPERATIONAL CONSTRAINT LIMITING PROCESS APPLICATION TO WARMER CLIMATES. IN ADDITION, THE PROCESS IS NOT WITHOUT OPERATING DIFFICULTIES BECAUSE OF THE FORMATION OF CALCIUM CARBONATE SCALE.

BREAKPOINT CHLORINATION IS ALSO A BROADLY-APPLICABLE ALTERNATIVE. THIS TECHNIQUE CAN PRODUCE AN EFFLUENT WITH 0.5 MG/L OF NH_3-N FROM A FEED CONCENTRATION OF 20 MG/L NH_3-N AT A COST OF $0.04/1000 GAL. (ASSUMING CHLORINE AT 3¢/LB). THE TECHNIQUE WILL INCREASE THE TDS OF THE EFFLUENT, PRIMARILY CHLORIDE ION (7.6 PARTS CL/PART NH_3-N) BUT WILL OXIDIZE THE BULK OF THE NH_3 TO N_2 WHICH DOES NOT REPRESENT A POTENTIAL AIR POLLUTION PROBLEM.

THE RECENT SUCCESSFUL DEMONSTRATION, AT 2.5 MGD, OF USING HIGH PURITY OXYGEN IN THE ACTIVATED SLUDGE PROCESS HAS THE POTENTIAL TO SIGNIFICANTLY EXTEND THE UTILITY OF THE CURRENT INVESTMENT IN ACTIVATED SLUDGE FACILITIES AND REDUCE THE CAPITAL REQUIREMENT FOR FUTURE PLANTS OF THIS TYPE. A CONVENTIONAL 10-MGD ACTIVATED SLUDGE PLANT WILL COST SOME $0.035/1000 GAL. TO OPERATE, INCLUDING CAPITAL AMORTIZATION. COST REDUCTIONS OF 15% OR MORE APPEAR TO BE ATTAINABLE FOR NEW PLANTS UTILIZING OXYGEN. PERCENT SAVINGS ARE POTENTIALLY GREATER FOR

CONVERSION OF EXISTING OVERLOADED PLANTS TO OXYGEN. THESE COST SAVINGS ARE ATTRIBUTABLE TO THE REDUCED DETENTION TIME REQUIRED FOR THE OXYGEN SYSTEM TO ACHIEVE BOD REMOVAL. IN FULL-SCALE TESTS, FOR EXAMPLE, THE OXYGEN SYSTEM HAS ACHIEVED A 92% REDUCTION IN BOD IN A DETENTION TIME OF 2 HOURS COMPARED TO THE 6 HOURS REQUIRED BY A CONVENTIONAL DIFFUSED AIR SYSTEM.

A LIST OF FULL-SCALE PLANTS WHICH ARE BEING DESIGNED FOR OXYGEN AERATION IS SHOWN IN TABLE 3.

TABLE 3 - FULL-SCALE PLANTS DESIGNED FOR OXYGEN AERATION

LOCATION	FLOW, MGD	STATUS
DETROIT, MICHIGAN	300	BIDS SOLICITED
NEW YORK, NEW YORK	20	ON STREAM, FALL 71
WINNIPEG, CANADA	15	DESIGN
NEW ROCHELLE, NEW YORK	15	PLANS APPROVED
SPEEDWAY, INDIANA	12	DESIGN
YORK, PENNSYLVANIA	8	DESIGN

NITROGEN REMOVAL CAN ALSO BE INCORPORATED INTO A TREATMENT SCHEME BASED ON BIOLOGICAL PROCESSES. A THREE-STAGE BIOLOGICAL SYSTEM HAS BEEN DEVELOPED WHICH PROVIDES EXCELLENT PROCESS CONTROL FOR THE ATTAINMENT OF HIGH EFFICIENCY REMOVAL OF CARBON AND NITROGEN. THIS SYSTEM, IF AUGMENTED WITH CHEMICAL ADDITION TO THE AERATOR, CAN PROVIDE CONTROL OF BOTH PHOSPHORUS AND NITROGEN NUTRIENTS.

CARBONACEOUS MATERIALS ARE OXIDIZED IN THE FIRST STAGE FOLLOWED BY NITRIFICATION OF THE AMMONIA IN THE SECOND STAGE AND DENITRIFICATION IN THE THIRD STAGE, A CARBON SOURCE, SUCH AS METHANOL, IS REQUIRED FOR THE THIRD-STAGE DENITRIFICATION. OVER-ALL NITROGEN REMOVAL

EFFICIENCIES OF 90% ARE OBTAINABLE. THE INCREMENTAL COST FOR ACHIEVING NITRIFICATION IN A 10-MGD FACILITY IS BETWEEN 3¢ AND 4¢/1000 GAL. AND, FOR DENITRIFICATION, BETWEEN 4¢ AND 5¢/1000 GAL. FIVE FULL-SCALE DEMONSTRATIONS OF THIS TECHNOLOGY, AT PLANT FLOWS AS HIGH AS 25 MGD, ARE EXPECTED TO BE INITIATED NEXT YEAR.

WHILE MUCH NEW PROCESS TECHNOLOGY HAS BEEN DEVELOPED FOR MUNICIPAL POLLUTION CONTROL APPLICATIONS, THESE SAME TECHNIQUES ARE FINDING APPLICATION IN THE AREAS OF INDUSTRIAL, AGRICULTURAL AND MINING POLLUTION CONTROL.

INDUSTRIAL WASTES

INDUSTRIAL WASTES ARE, OF COURSE, HIGHLY DIVERSE IN NATURE. INDUSTRIAL WASTE COMPONENTS INCLUDE ACIDS, ALKALIES, SALTS, NUTRIENTS, TOXIC MATERIALS, ORGANIC AND INORGANIC SOLIDS, OIL AND GREASE AND EVEN HEAT. EVEN WITH REGARD TO BOD, HOWEVER, IN THE U.S. INDUSTRIAL WASTES REPRESENT A GREATER BOD LOAD THAN DO ALL MUNICIPAL WASTES COMBINED. THE BOD_5 POPULATION EQUIVALENT FOR U.S. INDUSTRIAL SOURCES EXCEEDS THAT OF 400 MILLION PEOPLE.

IN THE U.S., AS WITH YOU HERE IN EUROPE, WE ARE SEEKING TO DEVELOP AND DEMONSTRATE BETTER METHODS OF TREATMENT AND CONTROL FOR WASTES FROM INDUSTRY. PART OF THIS GOAL, AND A PART OF EVER-INCREASING IMPORTANCE, IS TO DEVELOP CLOSED-LOOP SYSTEMS FOR RECOVERY AND REUSE OF THE WATER IN INDIVIDUAL INDUSTRIAL PROCESSES OR IN INDUSTRIAL COMPLEXES.

UNDER ITS INDUSTRIAL POLLUTION CONTROL RESEARCH PROGRAM, THE ENVIRONMENTAL PROTECTION AGENCY ASSUMES PART OF THE RISK OF DEVELOPING NEW TECHNOLOGY AND PROMOTES AND DEMONSTRATES IMPROVED METHODS FOR INDUSTRIAL POLLUTION CONTROL THROUGH A PROGRAM OF GRANTS DIRECT TO INDUSTRY. THERE ARE OVER 170 COMPLETED OR ON-GOING PROJECTS IN THIS EPA INDUSTRIAL WASTE CONTROL DEMONSTRATION PROGRAM. IT IS BEYOND THE SCOPE OF THIS PAPER TO DISCUSS PROGRESS IN ALL OF THE INDUSTRIAL CATEGORIES. HIGHLIGHTS OF MAJOR ACCOMPLISHMENTS ARE PRESENTED.

WHEN A BENEFICIAL USE FOR WASTE PICKLE LIQUOR, SUCH AS UTILIZING IT FOR PHOSPHORUS PRECIPITATION FROM MUNICIPAL WASTES, IS NOT ECONOMICALLY PRACTICABLE, THE WASTE CAN, NONETHELESS, BE TREATED ECONOMICALLY. A TECHNIQUE FOR TREATING THE ACID RINSE WATERS PRODUCED BY THE HCL PICKLING OF STEEL STRIP PREPARATORY TO COLD ROLLING HAS BEEN SUCCESSFULLY DEMONSTRATED AT A SCALE OF 2.2 MGD. THE ACID RINSE WATERS ARE NEUTRALIZED BY LIMESTONE AND THE FERROUS IRON IS THEN OXIDIZED TO FERRIC IRON IN AERATION TANKS. POLYELECTROLYTES ARE USED TO FACILITATE THE SEDIMENTATION OF THE FERRIC HYDROXIDE FLOC. THE EFFLUENT FROM SUCH A SYSTEM IS CLEAR AND OF NEUTRAL PH BUT IT STILL CONTAINS HIGH LEVELS OF CHLORIDE (PERHAPS 1,000 MG/L). THE SETTLED SOLIDS FROM THE SEDIMENTATION STEP CAN BE DEWATERED ON A VACUUM FILTER AND DISPOSED OF BY LAND FILL. THIS TREATMENT SYSTEM COSTS ABOUT $0.20/1000 GAL. OR LESS THAN $0.05 PER TON OF STEEL. THIS SYSTEM SHOULD FIND INCREASING APPLICATION IN THE U.S. IN VIEW OF THE TREND OF THE STEEL INDUSTRY TO CONVERT TO HCL PICKLING.

ONE OF THE MOST WIDESPREAD AND INTRACTABLE PROBLEMS OF THE CHEMICAL INDUSTRY IS PHENOLIC WASTES. PHENOL IS A SERIOUS PROBLEM BECAUSE OF ITS WIDESPREAD OCCURRENCE, TOXICITY TO MANY BIOLOGICAL SPECIES AND THE TASTE IT CAN IMPART TO FISH AND OTHER SEAFOOD. FOR THE CHLORO-BENZENE PROCESS FOR THE MANUFACTURE OF PHENOLS, A UNIQUE, CLOSED-LOOP SYSTEM FOR TREATING AND RECOVERING PHENOLIC WASTES HAS BEEN DEMONSTRATED AT ONE QUARTER OF FULL-SCALE. THE EFFLUENT FROM THE PHENOL PRODUCTION FACILITY IS PASSED THROUGH A STEAM STRIPPER TO RECOVER BENZENE AND ACETONE AND IS THEN COOLED IN A HEAT EXCHANGER BEFORE BEING APPLIED TO TWO ACTIVATED CARBON ADSORPTION COLUMNS IN SERIES. PHENOL IS REMOVED IN THE FIRST COLUMN FROM (15-200 MG/L DOWN TO 4 MG/L). THE EFFLUENT IS THEN ACIDIFIED TO A PH OF 3 WITH HCL AND THEN ACETIC ACID IS ADSORBED ON A SECOND CARBON COLUMN. PHENOL AND ACETATE ARE RECOVERED FROM THE CARBON BY CHEMICAL ELUTRIATION WITH CAUSTIC AND ARE RECYCLED FOR REUSE. THE EFFLUENT BRINE FROM THE CARBON COLUMNS IS ALSO RECYCLED AS A FEED STOCK FOR CHLORINE CAUSTIC PRODUCTION. FINAL PHENOL CONCENTRATION IN THE RETURN FLOW IS AS LOW AS 0.1 MG/L.

NOT ALL FORMS OF POLLUTION ARE AS INVISIBLE TO THE EYE AS THE TOXIC EFFECTS OF PHENOLS. SOME POLLUTANTS, SUCH AS COLOR BODIES ARE MUCH MORE VISUALLY EVIDENT AND ARE AESTHETICALLY UNACCEPTABLE. KRAFT PULPING AND PAPER MAKING PRODUCE EFFLUENTS WITH AS MUCH AS 1,400 PLATINUM COBALT UNITS OF COLOR. LIME CLARIFICATION OF THIS EFFLUENT CAN ACHIEVE AN 85-90% REDUCTION IN COLOR AT A COST OF ABOUT 36¢/1000 GAL. THIS IS EQUIVALENT TO AROUND $4 PER TON OF PULP PROCESSED. THIS COST COULD BE SIGNIFICANTLY REDUCED IF A SYSTEM OF RECALCINATION,

SIMILAR TO THAT USED TO RECOVER AND REUSE LIME-PHOSPHATE SLUDGES FROM MUNICIPAL TREATMENT PLANTS, WERE DEVELOPED. DEVELOPMENTAL EFFORTS ARE NOW UNDERWAY.

THE DEVELOPMENT OF ALTERNATIVE METHODS OF SLUDGE DISPOSAL IS AN ESSENTIAL INGREDIENT TO PROVIDING "PACKAGED TECHNOLOGY." SOME RECENT AND INTERESTING APPLICATIONS OF SLUDGE RECOVERY AND REUSE CONCEPTS HAVE BEEN DEVELOPED. THE PRIMARY SLUDGE FROM A PULP AND PAPER MILL PLANT, FOR EXAMPLE, CAN BE DEWATERED ON A PRESSURE DRUM FILTER (TECHNOLOGY BORROWED FROM EUROPE) AND USED AS (1) A SUPPLEMENTAL FUEL ("HOG FUEL") FOR CONVENTIONAL STEAM BOILERS, (2) A DRY MULCHING MATERIAL FOR HIGHWAY SLOPES, OR (3) AN AGRICULTURAL SOIL CONDITIONER. IN THE FOOD PROCESSING AREA, THE PEEL, SEEDS AND LOW-GRADE MOLASSES WASTES FROM A CITRUS JUICE CONCENTRATING PLANT CAN BE DRIED, PELLETIZED AND SOLD FOR AS MUCH AS $80/TON AS A CATTLE FEED SUPPLEMENT. MOREOVER, THE WASTE ACTIVATED SLUDGE FROM THE BIOLOGICAL TREATMENT PLANT AT THIS LOCATION IS BEING DRIED AND SOLD AT $240/TON AS A CHICKEN FEED SUPPLEMENT WHICH IS HIGH IN PROTEIN AND VITAMIN B-12. THE REVENUES FROM THE SALE OF THESE "BY-PRODUCTS" ARE MORE THAN ADEQUATE TO COVER THE COST OF THE ENTIRE WASTEWATER TREATMENT PLANT. THE DEMONSTRATION PLANT AT WINTER GARDEN, FLORIDA, IS BEING EXPANDED TO MEET THE INCREASING DEMAND FOR THESE "BY-PRODUCTS" WHICH HAS BEEN GENERATED BY THE LOCAL FARMERS.

THE DISPOSAL OF API SEPARATOR SLUDGE, TANK BOTTOM SLUDGE AND SPENT CAUSTIC HAS ALWAYS BEEN A SERIOUS PROBLEM IN THE PETROLEUM INDUSTRY. PIT STORAGE, BURIAL AND OPEN BURNING HAVE BEEN PARTIAL AND, FRANKLY,

UNSATISFACTORY SOLUTIONS IN THE PAST. A 70-BARREL/DAY FLUID BED INCINERATION SYSTEM FOR THE TREATMENT OF REFINERY CHEMICALS AND OIL SLUDGES HAS BEEN SUCCESSFULLY DEMONSTRATED. THE FACILITY IS ACTUALLY A MODIFICATION OF A COMMERCIALLY-AVAILABLE PROCESS WHICH WAS ORIGINALLY DESIGNED TO PROCESS SULFITE WASTES FROM THE PAPER INDUSTRY. AT LEAST THREE MAJOR OIL COMPANIES IN THE U.S. ARE INSTALLING SIMILAR WASTE CONTROL FACILITIES AT SEVERAL OF THEIR PLANT SITES.

THE METHODOLOGY DISCUSSED SO FAR HAS FOCUSED ON "TREATMENT" AS THE PRIMARY POLLUTION ABATEMENT TECHNIQUE. CONTROL OF POLLUTION AT ITS SOURCE OR CONTROL OF WATER USE ARE ALSO IMPORTANT POLLUTION ABATEMENT TECHNIQUES. AN EXCELLENT EXAMPLE OF IN-PROCESS CONTROL HAS RECENTLY BEEN DEMONSTRATED IN THE CANNING INDUSTRY. A DRY, CAUSTIC PEELING TECHNIQUE, CAPABLE OF ELIMINATING 90% OF THE WATER-USE REQUIREMENTS AND ASSOCIATED BOD FROM THE PEELING OPERATION, HAS BEEN DEMONSTRATED AT FULL SCALE FOR POTATO PROCESSING AND IS NOW BEING EVALUATED FOR SWEET POTATO AND TABLE BEET PROCESSING. THE POTATOES ARE DIPPED IN A LYE BATH AND TRANSPORTED ON A CONVEYOR, AT A CONTROLLED SPEED TO REGULATE THE PENETRATION OF LYE, TO AN INFRARED GAS-FIRED BURNER. THE BURNER BAKES THE PEEL OFF AND RESIDUAL FLAKES OF PEEL ARE CLEANED BY A SERIES OF RUBBER-TIPPED ROLLERS. THE POTATOES ARE THEN GIVEN A MINIMUM VOLUME HIGH-PRESSURE RINSE AS A FINAL POLISHING STEP. SUCH A DRY CAUSTIC PEELER COSTS APPROXIMATELY $98,000/LINE (20,000 LBS/HR.) COMPARED TO $29,000/LINE FOR CONVENTIONAL PEELING EQUIPMENT. HOWEVER, ACTIVATED SLUDGE TREATMENT OF POTATO WASTES COSTS ABOUT $0.06/LB.

BOD_5 REMOVED AND, BASED ON THE REDUCED HYDRAULIC AND BOD LOAD TO THE TREATMENT PLANT AND THE SAVINGS IN CAUSTIC AND OPERATING COSTS FOR THE PEELING OPERATION, THE DRY CAUSTIC PEELER WILL PAY FOR ITSELF IN LESS THAN FOUR MONTHS. THERE ARE OVER 15 INSTALLATIONS IN THE U.S. TODAY USING THIS TECHNIQUE WITH AN ADDITIONAL 35 ON ORDER.

A MODIFICATION OF THE DRY CAUSTIC PEELING TECHNIQUE WHICH ELIMINATES THE INFRARED BURNER IS BEING EVALUATED FOR THE PEELING OF PEACHES, PEARS AND APRICOTS WITH THE POTENTIAL OF REDUCING THE WATER-USE REQUIREMENTS BY 95%.

PEELING IS, OF COURSE, ONLY ONE STEP IN FOOD PROCESSING. THE OTHER TWO MAJOR WATER-USE STEPS ARE TRANSPORT AND BLANCHING. WE HAVE DEMONSTRATED, AT 8.6 MGD, THE TREATMENT, RECOVERY AND REUSE OF BEET TRANSPORT WATER AND ARE NOW EVALUATING VARIOUS TYPES OF STEAM, HOT WATER, MICROWAVE AND HOT AIR PILOT BLANCHERS IN AN ATTEMPT TO REDUCE THE WATER-USE REQUIREMENTS FOR THIS OPERATION BY 50% OR MORE.

AGRICULTURAL WASTES

AGRICULTURAL POLLUTION INCLUDES NUTRIENTS FROM FERTILIZER RUNOFF, SALTS AND PESTICIDES FROM IRRIGATION RETURN FLOWS AND BOD AND SOLIDS FROM CONFINED ANIMAL FEEDLOTS. FEEDLOT WASTES ARE OF INCREASING CONCERN IN THE U.S. THE BOD_5 FROM A CONFINED ANIMAL PRODUCTION OPERATION CAN RANGE FROM 10,000-50,000 MG/L.

TO A LARGE DEGREE, THE MANAGEMENT TECHNIQUES OF CONFINED ANIMAL FEEDING HAVE INCREASED THE SEVERITY OF THE POLLUTION PROBLEM FROM THESE SOURCES BY CONCENTRATING THE WASTES IN LOCAL AREAS. ONE

IMPORTANT APPROACH TOWARD SOLVING THE ANIMAL FEEDLOT PROBLEM INVOLVES THE TECHNIQUES OF HOUSING OR ARRANGING THE ANIMALS IN A MANNER WHICH WILL MINIMIZE OR ELIMINATE THE WASTE COLLECTION AND TRANSPORT PROBLEMS. FOR EXAMPLE, A TECHNIQUE OF CAGING HENS AND SUSPENDING THEM OVER AN OXIDATION DITCH HAS BEEN DEMONSTRATED FOR A 250-HEN OPERATION. THE WASTES ARE BIOLOGICALLY STABILIZED IN THE OXIDATION DITCH PRIOR TO LAND DISPOSAL OF THE SLUDGE. THE OPERATION IS SUPERIOR TO THE ALTERNATIVE OF DRY CONVEYOR COLLECTION BOTH IN TERMS OF ODOR CONTROL AND OF PRODUCING A STABILIZED SLUDGE. THE COST OF THE OXIDATION DITCH TREATMENT IS BETWEEN I¢ AND 4¢ PER DOZEN EGGS PRODUCED. AN INTERESTING OBSERVATION HAS BEEN THAT SWINE CAN BE TRAINED TO WALK OVER A SEPARATE SLOTTED FLOOR AREA TO DEPOSIT THEIR WASTES DIRECTLY INTO AN OXIDATION DITCH BELOW. THE JUDICIOUS PLACEMENT OF THEIR FOOD SUPPLY DIRECTLY ACROSS THE SLOTTED FLOOR FROM THE PEN AREA PROVIDES THE NEEDED INDUCEMENT. UNFORTUNATELY, CATTLE ARE NOT QUITE SO COOPERATIVE. OPEN FEED AREAS WITH TIGHT SOIL AND PROPER RUNOFF COLLECTION FACILITIES CAN, HOWEVER, PROVIDE ADEQUATE CONTROL. LOOSE SOIL AND POOR DRAINAGE ARE NOT ONLY UNDESIRABLE FROM A WASTE MANAGEMENT STANDPOINT, BUT ALSO FROM A BEEF PRODUCTION PERSPECTIVE. CATTLE CAN LOSE 50% OR MORE OF THEIR NORMAL WEIGHT GAIN DURING THE SUMMER MONTHS BY WALKING AROUND IN UNCONSOLIDATED MUDDY SOIL. SEVERAL ALTERNATIVE COLLECTION SYSTEMS ARE AVAILABLE FOR CONFINED CATTLE FEEDLOTS. THESE INCLUDE MECHANICAL SCRAPERS, SLOTTED FLOORS AND SLOPED FLOORS.

BIOLOGICALLY STABILIZED FEEDLOT WASTES CAN OFTEN BE DISPOSED OF BY LAND SPREADING THE SLUDGE AND SPRAY IRRIGATING THE EFFLUENT.

WHERE THE SIZE OF THE OPERATION OR THE LOCAL SOIL CONDITIONS PRECLUDE USE OF LAND DISPOSAL, ADVANCED WASTE TREATMENT NUTRIENT REMOVAL TECHNIQUES, SIMILAR TO THOSE USED FOR MUNICIPAL POLLUTION CONTROL, CAN BE USED PRIOR TO DISCHARGE. THE NUTRIENT CONCENTRATION OF ANIMAL FEEDLOT WASTES, AS FOR BOD_5, IS SIGNIFICANTLY HIGHER THAN MUNICIPAL WASTE CONCENTRATIONS. FOR EXAMPLE, PHOSPHORUS CONCENTRATIONS AS HIGH AS 110 MG/L AS P ARE NOT UNCOMMON IN POULTRY WASTES. CHEMICAL COSTS TO ACHIEVE 80% PHOSPHORUS REMOVAL FROM POULTRY WASTES ARE $0.40 TO $0.53 PER 1000 GAL. FOR LIME AND ALUM RESPECTIVELY. DOSING REQUIREMENTS AVERAGE ALMOST 1100 MG/L FOR ALUM AND 4,400 MG/L FOR LIME. LIME TREATMENT HAS THE ADDED ADVANTAGE OF PROVIDING SUPERIOR COLOR REMOVAL BUT INCREASES THE SLUDGE HANDLING REQUIREMENTS.

IRRIGATION RETURN FLOWS ARE ANOTHER SIGNIFICANT SOURCE OF AGRICULTURAL POLLUTION. THE INCREASE IN SILT AND TOTAL DISSOLVED SOLIDS IS SIGNIFICANT BUT THE INCREASE IN NITRATES MAY OFTEN BE OF SPECIAL IMPORTANCE BECAUSE OF POTENTIAL HEALTH EFFECTS IN DRINKING WATER SUPPLIES. AT FIREBAUGH, CALIFORNIA, DENITRIFICATION OF IRRIGATION RETURN FLOWS, BY ADDING METHANOL AND PASSING THE FLOW THROUGH A COARSE MEDIA UPFLOW CONTACTOR, HAS BEEN SUCCESSFULLY DEMONSTRATED. THE NITRATE CONCENTRATION CAN BE REDUCED FROM 25 MG/L TO 2 MG/L. APPLICATION OF THIS TECHNIQUE IN THE SAN JOAQUIN DRAINAGE BASIN, FOR EXAMPLE, WOULD REDUCE THE NITRATE LOAD TO SAN FRANCISCO BAY BY 125,000 LBS PER DAY. DENITRIFICATION TECHNOLOGY UTILIZED IN MUNICIPAL POLLUTION CONTROL IS SIMILAR.

OTHER URBAN WASTES

THE CATEGORY, "OTHER URBAN WASTES," INCLUDES STORM AND COMBINED SEWER DISCHARGES, URBAN RUNOFF AND UNSEWERED MUNICIPAL WASTES. OTHER URBAN WASTES HAVE MANY OF THE SAME ADVERSE EFFECTS ON WATER QUALITY AND WATER USE AS MUNICIPAL SEWAGE. THEY CONTAIN HIGH CONCENTRATIONS OF BACTERIA, SOLIDS, ORGANICS AND INORGANICS. THE PRIMARY DIFFERENCE BETWEEN THESE WASTES AND MUNICIPAL SEWERED WASTES IS THEIR FREQUENCY AND UNPREDICTABILITY OF OCCURRENCE AND THEIR VARIABILITY IN HYDRAULIC LOAD. SEPARATION OF STORM AND SANITARY SEWERS, ONCE THOUGHT TO BE THE ULTIMATE SOLUTION TO THE COMBINED SEWER PROBLEM, IS OF QUESTIONABLE APPLICABILITY IN MANY LOCATIONS BECAUSE OF COST, PHYSICAL DISRUPTION OF NORMAL URBAN ACTIVITIES DURING CONSTRUCTION PERIODS AND THE REALIZATION THAT EVEN SEPARATED STORM FLOWS MAY HAVE HIGH POLLUTION POTENTIAL DUE TO SUSPENDED SOLIDS, BOD AND BACTERIA. ONE SOLUTION IS TO BUILD OPTIMIZED STORM FLOW COLLECTION AND TREATMENT SYSTEMS. BECAUSE OF THE INTERMITTENT NATURE AND MAGNITUDE OF FLOWS TYPICAL OF THESE WASTES (1 TO 100 TIMES GREATER THAN DRY WEATHER FLOWS), THE UTILIZATION FACTOR OF CAPITAL INVESTED IN FACILITIES WILL BE LESS THAN FOR SYSTEMS WHERE WASTE FLOWS APPROACH STEADY-STATE CONDITIONS. TECHNIQUES WHICH ARE RELATIVELY LOW IN CAPITAL COST, IN SPITE OF RELATIVELY HIGH OPERATING COSTS, ARE PREFERRED FOR THESE APPLICATIONS. THERE IS A REAL PREMIUM TO BE GAINED BY USING UNIT PROCESSES CAPABLE OF HIGH FLOW RATES SUCH AS MICROSTRAINING, FINE SCREENING, DISSOLVED AIR FLOTATION OR HIGH RATE (20 GPM/FT^2) MEDIA FILTRATION. FOR EXAMPLE, IN PHILADELPHIA, PENNSYLVANIA, THE POTENTIAL UTILITY OF MICROSTRAINING OF COMBINED

SEWER FLOWS AT 45 GPM/FT^2 WAS DEMONSTRATED. MICROSTRAINERS, ROTARY DRUM SCREENS OFTEN USED FOR ALGAE REMOVAL IN WATER TREATMENT, HAVE ALSO BEEN DEMONSTRATED TO HAVE REAL VALUE FOR TERTIARY SOLIDS REMOVAL FROM TREATED MUNICIPAL SEWAGE. IN FACT, A 15-MGD FACILITY IS NOW UNDER CONSTRUCTION IN CHICAGO, ILLINOIS. USING A 23-MICRON SCREEN, THE SUSPENDED SOLIDS REMOVAL EFFICIENCY IN THIS APPLICATION HAS RANGED FROM 62% TO 96% AND HAS AVERAGED 80%. VOLATILE SUSPENDED SOLIDS REMOVAL AVERAGED 71%. ESTIMATES OF THE COST OF MICROSTRAINING AND CHLORINATION (5 TO 20 PPM DOSE) OF STORM RUNOFF ARE ON THE ORDER OF $9,000 PER MGD OR $11,000 PER ACRE OF DRAINAGE TREATED. THIS COST, WHILE HIGH, IS ONLY 40-50% OF THE ESTIMATED COST OF SEPARATING STORM AND SANITARY SEWERS WHICH HAS BEEN ESTIMATED TO BE $20,000-$23,000 PER ACRE.

FINE SCREENING (297 MICRONS) AND DISSOLVED AIR FLOTATION WITH ALUM AND POLYMER COAGULATION OF COMBINED SEWER OVERFLOWS WAS DEMONSTRATED AT 5 MGD IN MILWAUKEE, WISCONSIN, REDUCTIONS OF UP TO 98% SUSPENDED SOLIDS, 79% BOD AND 92% OF THE PHOSPHORUS CONCENTRATIONS IN THE WET WEATHER FLOW WERE MEASURED. THE CAPITAL COST OF THIS TYPE OF INSTALLATION IS ABOUT $12,000 PER MGD OF CAPACITY (APPROXIMATELY $.01 PER DAILY GALLON) OR $9,000-$14,000/ACRE. OPERATING COSTS ARE 3¢-4¢/1,000 GALLONS TREATED.

CONTROL TECHNIQUES ARE ALSO A VERY VITAL PART OF ABATING POLLUTION FROM STORM AND COMBINED SEWERS. CONTROL TECHNIQUES INCLUDE THE PHYSICAL ASPECTS OF ROUTING, DIVERSION AND CONTAINMENT OF EITHER STORMWATER OR COMBINED SEWAGE. IN-LINE AND OFF-LINE STORAGE DURING STORMS WITH

SUBSEQUENT DISCHARGE TO TREATMENT FACILITIES HAS REAL VALUE AND IS AN EXCELLENT WAY TO IMPROVE THE UTILIZATION FACTOR OF THE CAPITAL INVESTMENT IN COLLECTION AND TREATMENT FACILITIES. IN DETROIT, MICHIGAN, A MONITORING AND REMOTE CONTROL SYSTEM IS BEING DEMONSTRATED TO MAXIMIZE THE STORAGE CAPACITY OF THE EXISTING SEWER SYSTEM. NEW POWER-OPERATED DIVERSIONARY OVERFLOW STRUCTURES AND AUTOMATIC CONTROL INSTRUMENTATION HAVE BEEN INSTALLED TO MEASURE WASTEWATER FLOW, QUALITY, CONDUIT LIQUID LEVELS, AND TO CONTROL REMOTELY DIVERSION GATE OPERATIONS. TELEMETERING IS PROVIDED TO TRANSMIT AND RECORD DATA COLLECTED AND TO PROVIDE FEED-BACK DATA RELATIVE TO THE STATUS OF THE REMOTELY CONTROLLED UNITS.

ANOTHER POSSIBLE SOLUTION TO PART OF THE NON-SEWERED MUNICIPAL WASTE PROBLEM IS BEING DEMONSTRATED AT GRANDVIEW LAKE, INDIANA, AND ALBANY, NEW YORK. INDIVIDUAL GRINDER-PUMPS HAVE BEEN INSTALLED IN EACH HOUSE. WASTES ARE THEN DISCHARGED INTO SMALL DIAMETER, PLASTIC PRESSURIZED SEWERS. THE SEWAGE FROM A SMALL GROUP OF HOUSES IS COLLECTED AND TREATED IN A PACKAGE PLANT. THIS KIND OF SYSTEM MAY BE APPLICABLE WHERE DISTANTLY-SEPARATED HOMES OR ROCK EXCAVATION COSTS MAKE THE CONSTRUCTION OF CONVENTIONAL SEWERS PROHIBITIVELY EXPENSIVE.

OIL SPILLS

OIL SPILL PROBLEMS ARE RELATED PRIMARILY TO TRANSPORTATION ACTIVITIES SINCE ADEQUATE OVERFLOW CHANNELS, SECONDARY DIKING AND ALARM SYSTEMS CAN READILY BE DESIGNED TO MINIMIZE SPILLS FROM STATIONARY FACILITIES. DURING THE LAST SEVERAL YEARS OVER 150 MILLION GALLONS OF OIL HAVE BEEN RELEASED IN MAJOR SPILL INCIDENTS COSTING TENS OF MILLIONS OF DOLLARS TO CLEAN UP, AND THE POTENTIAL INSULTS TO THE ENVIRONMENT

FROM ACCIDENTAL SPILLS ARE INCREASING AS SHIPS GET LARGER (16,000-30,000 DWT TANKERS IN THE 1950'S COMPARED WITH 200,000-350,000 DWT TANKERS IN THE 1960'S AND 70'S) AND AS PIPELINES WHICH HAVE SERVED US WELL IN THE PAST ARE GETTING OLDER AND FAILING MORE FREQUENTLY.

A GREAT DEAL OF RESEARCH EFFORT IN THE UNITED STATES IS CURRENTLY BEING FOCUSED ON METHODS OF CONTAINMENT (BOOMS), MECHANICAL HARVESTING TECHNIQUES (AIR, WATER, MECHANICAL SWEEPS), PICKUP, SEPARATION AND DISPOSAL METHODS.

A 30,000-GAL. PER HR. OIL SKIMMING AND SEPARATION SYSTEM CAPABLE OF PRODUCING A DISCHARGE WATER OF LESS THAN 100 PPM AND A RECOVERED OIL CONTAINING LESS THAN 5 PERCENT WATER HAS BEEN SUCCESSFULLY DEMONSTRATED. THE OIL CONTENT OF THE DISCHARGE WATER COULD BE REDUCED TO LESS THAN 20 PPM IF REQUIRED BY RECYCLING IT THROUGH THE CENTRIFUGE A SECOND TIME. THE SKIMMING DEVICE IS A TWIN-HULLED BARGE WITH A PARTIALLY LOUVERED BOTTOM APPROPRIATELY BAFFLED TO ATTENUATE WAVE ACTION. SKIMMED OIL IS COLLECTED BY A FLOATING WEIR AND PUMPED TO A CENTRIFUGE (4,000G) CAPABLE OF HANDLING INLET EMULSION CONCENTRATIONS UP TO 5,000 PPM. THE OVER-ALL SYSTEM EFFICIENCY IS 99% WHEN OPERATING AT 0.5 KNOTS AND 80% AT 5 KNOTS UNDER SMOOTH SEA CONDITIONS. THE SYSTEM WILL OPERATE UNDER CONDITIONS UP TO AND INCLUDING SEA STATE 4 (MODERATE WAVES, WIND VELOCITY 20 KNOTS, WAVE HEIGHT 5 FT.), BUT WITH SOME LOSS IN EFFICIENCY. THIS SYSTEM, TOGETHER WITH BOOMS AND AN OIL STORAGE TANK, CONSTITUTES A COMPLETE OCEAN OIL SPILL RECOVERY SYSTEM.

WHAT CAN BE DONE WHEN AN OIL SLICK HAS ALREADY BEEN WASHED ON-SHORE AND CONTAMINATED THE BEACHES? EARLY ATTEMPTS TO CLEAN CONTAMINATED BEACHES WERE OFTEN SLOW, TEDIOUS AND EXPENSIVE OPERATIONS. A TECHNIQUE CAPABLE OF CLEANING 4.5 MILES OF CONTAMINATED BEACH IN ONE WORKING DAY HAS RECENTLY BEEN DEMONSTRATED. THE BEAUTY OF THE OPERATION IS THAT THE EQUIPMENT, OR SUITABLE SUBSTITUTES, IS ALMOST UNIVERSALLY AVAILABLE FOR CONTINGENCY SPILL CLEAN-UP OPERATIONS. THE EQUIPMENT INVOLVES A GRADER, AN ELEVATING SCRAPER AND AN IMAGINATIVE SYSTEMS APPROACH. THE OPERATOR OF THE GRADER (MODIFIED WITH HALF-TRACKS TO IMPROVE TRACTION IN THE SAND) STARTS HIS FIRST PASS FURTHEST INSHORE WITH THE MOLDBOARD SET AT A 40 DEGREE ANGLE WITH RESPECT TO THE DIRECTION OF TRAVEL. THE LAST PASS IS MADE AT THE SURF LINE WITH THE MOLDBOARD ANGLE CHANGED 100^{0} TO REVERSE THE DIRECTION OF CAST FROM SEAWARD TO LANDWARD. THE ELEVATING SCRAPER PICKS UP THE RESULTING WINDROW (MATERIAL DEPOSITED FROM THE TRAILING EDGE OF THE GRADER BLADE). THE PROCEDURE CAN BE USED TO CLEAN SECTIONS OF BEACH 200-300 YARDS AT A TIME. THIS IS AN EXCELLENT EXAMPLE OF UTILIZING COMMERCIALLY-AVAILABLE EQUIPMENT AND REMINDING US THAT POLLUTION CONTROL TECHNIQUES NEED NOT BE UNIQUE OR NOVEL, JUST EFFECTIVE.

ANOTHER FACET OF THE OVER-ALL OIL POLLUTION PROBLEM IS THE DISPOSAL OF USED MOTOR OILS. A SYSTEM EMPLOYING VACUUM DISTILLATION AND FRACTIONATION, CAPABLE OF HANDLING 9,000,000 GALLONS PER YEAR HAS BEEN DEMONSTRATED DURING THE LAST YEAR AND A HALF. THE USED CRANKCASE OIL

PROVIDES NO. 6 FUEL OIL (28.4%), NO. 4 FUEL OIL (36.8%), NO. 4 DIESEL OIL (20.8%), NO. 2 FUEL OIL (5.5%), GASOLINE ADDITIVE (0.5%) AND PROCESS FUEL FOR PLANT USE (5%). THE REMAINDER IS WATER. THE RECOVERED PRODUCTS ARE SUPPLEMENTED WITH FIRST GRADE MATERIALS AT A COST OF $0.003 TO $0.024/GAL TO MEET U.S. MARKET SPECIFICATIONS FOR PRODUCTS WHICH HAVE A RETAIL PRICE OF $0.05 TO $0.10/GALLON. DIRECT OPERATING COSTS FOR THE PLANT ARE $0.04/GAL.

CHANGES IN THE OIL INDUSTRY TO MULTI-GRADE MOTOR OILS WITH MUCH HIGHER ADDITIVE CONTENTS AND THE TREND OF AUTOMOBILE MANUFACTURERS TO GREATLY INCREASE THE MILEAGE AND TIME INTERVALS BETWEEN RECOMMENDED OIL CHANGES HAS SIGNIFICANTLY CHANGED THE COMPOSITION OF CRANKCASE OIL IN RECENT YEARS. PRETREATMENT STEPS OF CENTRIFUGATION, SOLVENT EXTRACTION AND CHEMICAL TREATMENT WILL HAVE TO BE INCORPORATED TO REMOVE THE SPENT AND DEGRADED ADDITIVES, SLUDGE AND TAR-FORMING MATERIALS PRODUCED BY PISTON BLOW-BY. SINCE PROCESS CHANGES ARE STILL BEING IMPLEMENTED TO HANDLE THE MORE DIFFICULT FEEDSTOCKS, ACCURATE FIGURES ON FUTURE EQUIPMENT REQUIREMENTS CANNOT BE MADE AT THIS TIME. AT THE PRESENT, HOWEVER, THE RECOVERY AND REUSE OF USED MOTOR OILS APPEARS TO BE MARGINALLY PROFITABLE. PROCESS OPTIMIZATION TO INCREASE THE YIELD OF PRODUCTS WITH A HIGHER RESALE VALUE COULD IMPROVE THE ECONOMICS.

MINING WASTES

EVERY YEAR MINING AND RELATED OPERATIONS CAUSE SOME 500 BILLION GALLONS OF MINE DRAINAGE CONTAINING MILLIONS OF TONS OF ACID AND ACID SALTS TO DEGRADE OVER 10 THOUSAND MILES OF SURFACE STREAMS AND 15 THOUSAND ACRES OF IMPOUNDED WATER IN THE APPALACHIAN REGION OF THE UNITED STATES.

SEVERAL INTERESTING PROCEDURES FOR ABATING ACID MINE POLLUTION HAVE BEEN DEVELOPED IN THE LAST TWO OR THREE YEARS. THE FIRST INVOLVES THE USE OF A PERMEABLE PLUG TO NEUTRALIZE AND SEAL ACID MINE DRAINAGE SOURCES IN ONE OPERATION. PULVERIZED LIMESTONE IS PNEUMATICALLY PLACED IN THE MINE PORTAL TO PROVIDE A CONTACT TIME OF APPROXIMATELY 25 MINUTES TO EFFECT NEUTRALIZATION OF SEEPAGE. IRON HYDROXIDE (AND POSSIBLY CALCIUM SULFATE) PRECIPITATED DURING THIS NEUTRALIZATION GRADUALLY FILLS THE PORES OF THE PLUG AND SEALS THE MINE OPENING. FIELD TESTS OF THIS TECHNIQUE HAVE INDICATED A REDUCTION IN FLOW FROM 7 GPM TO 0.5 GPM IN 55 DAYS AND THE PH OF THE ACID MINE WATER WAS RAISED FROM 3.I TO 5.8. A FINISHED SEAL IN AN ACTUAL MINE WITH A 4-I/3' BY I2' DRIFT HAVING 25 FEET OF ROOF CONTACT AND 36 FEET OF LENGTH ON THE BASE WAS PLACED AT THE RATE OF 850 POUNDS PER MINUTE AT A COST OF $3,048. THE FLOW OF 3 GPM HAS BEEN ESSENTIALLY STOPPED AND THE PLUG IS CURRENTLY WITHSTANDING A HYDROSTATIC HEAD OF 6.3 FT. ANALYSES INDICATE THAT THE PH OF THE ACID MINE WATER INCREASED FROM 3.0 TO 6.9 WITH A SIMULTANEOUS CHANGE FROM 300 MG/L OF ACIDITY TO I60 MG/L OF ALKALINITY.

A POTENTIAL BREAKTHROUGH IN MINE DRAINAGE TECHNOLOGY HAS RECENTLY BEEN DEVELOPED. THE PROCESS, "NEUTROLOSIS," UTILIZES NEUTRALIZATION AND REVERSE OSMOSIS IN COMBINATION. MINE DRAINAGE IS PRE-FILTERED AND THEN PASSED THROUGH A MULTI-STAGE REVERSE OSMOSIS UNIT. THE CONCENTRATED BRINE IS NEUTRALIZED WITH LIME AND CLARIFIED. THE CLARIFIED EFFLUENT CAN BE RECYCLED AND BLENDED WITH THE FEED TO THE R.O. UNIT. THIS PROCESS RECOVERS 98% OF THE DRAINAGE WATER,

PRODUCES A SLUDGE SUITABLE FOR DISPOSAL BY SIMPLE LANDFILL AND COMPLETELY ELIMINATES THE BRINE DISPOSAL PROBLEM. OVER-ALL REJECTION EFFICIENCIES OF 97-98% HAVE BEEN OBTAINED FOR CALCIUM, MAGNESIUM, SULFATE, IRON AND ALUMINUM ALONG WITH 79% REDUCTION IN CONDUCTANCE AND 92% REDUCTION IN ACIDITY. AVERAGE WATER RECOVERY FOR THE R.O. UNIT WAS 91% AT A WATER FLUX OF JUST OVER II GAL/FT^2/DAY. A FLUX DECLINE OF LESS THAN 2 GAL/FT^2/DAY WAS NOTED IN 100 HOURS OF OPERATION BUT THE MEMBRANE FOULING WAS NOT IRREVERSIBLE AND COULD BE CONTROLLED BY RAPID PRESSURE CHANGES AND A FLUSH CYCLE. LARGER-SCALE, LONG-TERM EVALUATIONS ARE CURRENTLY BEING MADE TO DETERMINE MEMBRANE LIFE AND OBTAIN ACCURATE COST INFORMATION.

IN ADDITION TO TRANSFERRING TECHNOLOGY WE MUST ALL BE ON THE LOOK-OUT FOR TECHNOLOGY FROM OTHER DISCIPLINES WHICH CAN BE ADOPTED FOR ENVIRONMENTAL PROTECTION. OUR MINE POLLUTION CONTROL RESEARCH PROGRAM HAS, FOR EXAMPLE, LOOKED TO SPACE TECHNOLOGY FOR A POSSIBLE ANSWER. ONE VERY DESIRABLE WAY OF ATTACKING THE ACID MINE DRAINAGE PROBLEM IS TO PREVENT THE FORMATION OF THE ACID DRAINAGE IN THE FIRST PLACE. WE ARE CURRENTLY EVALUATING THE CONCEPT OF MINING COAL IN AN OXYGEN-FREE ATMOSPHERE. MINERS ARE EQUIPPED WITH MODIFIED "SPACE SUITS" COMPLETE WITH THEIR OWN LIFE SUPPORT SYSTEMS INCLUDING AN EMERGENCY REBREATHER, RADIO TRANSMITTER/RECEIVER AND AN UMBILICAL HOSE WHICH IS CONNECTED TO EITHER A PORTABLE REBREATHER OR A FIXED REBREATHER-CHILLER MODULE. THE SUIT HAS THREE LAYERS, AN UNDERGARMENT TO ABSORB BODY MOISTURE, A GAS-TIGHT MIDDLE GARMENT AND A HEAVY-DUTY OUTER WORK GARMENT. THE MINE, EQUIPPED WITH A GAS LOCK CURTAIN

AT THE MINE PORTAL, IS FILLED WITH AN INERT GAS, E.G., NITROGEN OR METHANE. MODIFICATION OF EXISTING CONVENTIONAL MINING EQUIPMENT WILL BE MINIMAL FOR SUCH AN OPERATION. THE COMPLETED FEASIBILITY STUDY INDICATES THAT THE COST OF EQUIPPING A 5,000-TON-PER-DAY UNDERGROUND COAL MINE WITH INERT GAS BLANKETING WOULD NOT INCREASE THE INSTALLED COST OF THE MINE BY MORE THAN 12%. IN A NON-GASSY MINE, THE OPERATING COSTS OF INERT GAS OPERATION MAY INCREASE THE OPERATING COSTS OF THE MINE BY A FEW PERCENT BUT IN THE CASE OF A GASSY COAL MINE, OPERATION IN AN INERT GAS ATMOSPHERE MAY ACTUALLY DECREASE THE COST OF THE MINE OPERATION BY AS MUCH AS 20% WHEN CREDIT IS APPLIED FOR THE METHANE GAS THAT IS COLLECTED AND SOLD. WHILE THIS MINING CONCEPT MUST STILL BE REGARDED AS IN AN EXPLORATORY STAGE, IT HOLDS SUBSTANTIAL PROMISE FOR ULTIMATE PRACTICABILITY, ESPECIALLY CONSIDERING THE ADVANTAGES IN HEALTH (ELIMINATION OF BLACK LUNG DISEASE) AND SAFETY (ELIMINATION OF EXPLOSION HAZARD) WHICH THE APPROACH MAY OFFER.

CONCLUSION

A VARIETY OF NEWLY-DEVELOPED, COST-EFFECTIVE TREATMENT AND CONTROL TECHNIQUES ARE AVAILABLE TO ABATE POLLUTION FROM MANY MAJOR SOURCES. MANY OF THESE TECHNIQUES HAVE ALREADY BEEN DEMONSTRATED AT FULL SCALE AND ARE READY FOR WIDE-SCALE APPLICATION. MANY NEW TECHNIQUES, WHICH INCORPORATE THE VERY DESIRABLE ASPECTS OF BY-PRODUCT RECOVERY AND REUSE, ARE ALSO AVAILABLE WHICH CAN STIMULATE NEW INDUSTRIAL ACTIVITIES AND CHANGE THE ECONOMICS OF VARIOUS PRODUCT LINES. POLLUTION CONTROL

ACTIVITIES, IN SOME INSTANCES, ARE EVEN PROFIT-MAKING AND RESOURCE CONSERVATION OPPORTUNITIES IN ADDITION TO BEING AN INCREASINGLY NECESSARY PART OF MAN'S RESPONSIBILITY TO HIMSELF AND HIS CHILDREN TO PRESERVE THE ENVIRONMENT.

I'M PERSONALLY CONFIDENT OF MAN'S ABILITY TO CONTROL POLLUTION AND I'M ENTHUSIASTIC ABOUT FUTURE PROSPECTS FOR ACHIEVING A CLEAN ENVIRONMENT THROUGH TECHNOLOGY TRANSFER AND IMAGINEERING. IT IS MY HOPE THAT HISTORY WILL RECORD THAT IN THE SAME DECADE THAT MAN FIRST REACHED AND EXPLORED THE MOON HE ALSO REALIZED THE FINITE NATURE OF THE EARTH AND ITS ENVIRONMENT; THAT HE "RETURNED" TO PROTECT IT AND THAT HE SUCCEEDED!